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Social Impact Analysis of Retracted Paper in the Context of Public Health Emergencies

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Abstract

Analyzing the impact of COVID-19 retracted papers can provide references for effectively preventing and controlling negative effects. In this study, 253 COVID-19 retracted papers in Retraction Watch were selected as research objects. Focusing on the paper publication and the retraction notice release, this study analyzes their social impact from three aspects: social attention, public dissemination and policy making. Meanwhile, this study takes typical retracted papers as examples to analyze the impact cascade phenomenon it may trigger. The results show that paper characteristics, delay in retraction, and reasons for retraction play an important role in the social impact of COVID-19 retracted papers, which is highly concentrated. The faster papers gains public attention, the longer the duration of their attention will be. Some papers could be used in policy documents soon after publication, often by referring to the conclusions and discussion sections to enhance persuasion. On this basis, this study proposes strategies to prevent and control the negative impact of retracted papers. First, journals should pay attention to the standardization of the retraction process and statement. Second, researchers should consider public needs and emphasize the social value of scientific research. Third, the supervision department should play an important role in accelerating the process of academic purification through news media and social media. When utilizing academic achievements, policymakers should adequately assess the quality of papers and update retraction information promptly.

Introduction

Retraction serves as a self - correction mechanism within the scientific community, aiming to purify and uphold scientific research ethics. In recent years, there has been an increase in the number of retracted papers due to data issues, image issues, authorship issues, plagiarism and false reviews. The number of retracted papers worldwide per year has risen from 41 in 2000 to over 10,000 in 2023 (Van Noorden, 2023), hitting an all-time high. Retracted papers may confuse subsequent research

with erroneous data or opinions, even mislead practice or decision-making in the wider society. This harms human health, public safety or social development.

Public health emergency is a major infectious disease outbreak or mass unexplained disease that occurs suddenly and may cause serious damage to public health. To effectively prevent, control and eliminate its harm, China formulated *the Regulations on Public Health Emergencies* in 2003. It emphasizes that medical, monitoring, scientific research and other institutions should obey the unified command of the headquarters and concentrate on relevant scientific research work. Academic achievements are disseminated and utilized in academic circles and all sectors of society, providing decision-making support regarding public health emergencies. After the outbreak of COVID-19, international medical journals have responded to the severe situation caused by the epidemic from three aspects: speeding up peer review, open access, and improving data mining and analysis tools (Shen, 2022). The rapid publication of a large number of academic papers has not only greatly facilitated scholarly communication and information sharing, vaccine research and clinical practice in the field of COVID-19, but has also attracted widespread attention from the government and the public, playing an important role in the formulation of epidemic prevention and control policies (Ren et al., 2023; Ren & Yang, 2023), the analysis of the "infodemic" phenomenon (Geng, 2020), and responses to it (Caulfield, 2020; Li et al., 2021). However, there were also very serious retraction problems during that period (Yeo-Teh & Tang, 2022), involving many top medical journals such as *the New England Journal of Medicine* and *the Lancet*. For example, *The Lancet* published a paper reporting that the use of hydroxychloroquine was associated with a higher risk of ventricular arrhythmias and increased in-hospital mortality among COVID-19 patients (Mehra et al., 2021). The results of this study led some countries to ban the use of hydroxychloroquine for the treatment of COVID-19 and suspend clinical trials. This study was later retracted due to uncertain data authenticity. The World Health Organization then restarted trials of the drug hydroxychloroquine. When the paper was published, it attracted great attention worldwide and was reported by 236 mainstream media outlets on the same day. It was mentioned more than 5,000 times on Twitter, blogs, and other social media platforms. Ultimately, it not only shook the public perception but also had a significant negative impact on clinical practice. This suggests that the social impact of retracted papers is not static. Rather, it evolves at landmark events such as paper publication, multiple challenge investigations, and retraction notice releases. When the epidemic prevention and control entered a stable period, scholars conducted in-depth research on COVID-19. Academic papers published in the early stage of the

epidemic were retracted and even a series of retractions resulted from large-scale investigations. The "positive impact" of some papers before the retraction may hide major errors, which are potentially harmful and should not be ignored. Therefore, it is necessary to explore the social impact triggered by retracted papers, especially focusing on the impacts of these papers on public cognition and policy-making. This will provide references for effective prevention and control of the negative effects.

Since the concept of retraction was first introduced in the 1980s, academics have begun to focus on several aspects: the construction of the retraction system (Resnik et al., 2015; Yang, 2020), the basic characteristics of retracted papers (e.g., time, subject, and country distribution) (Song & Yang, 2023), the characteristics of retractions (e.g., reason for retraction, delay in retraction) (Rubbo et al., 2022; Sun et al., 2023), as well as the academic impact (Yuan & Jin, 2024) and social impact (Khan et al., 2022; Liu, Wang, et al., 2022) after retraction. Focusing on the field of COVID-19, the social impact of retracted papers is mostly reflected in the Altmetric Attention Score (AAS). Khan et al. (2022) found that the 22 retracted papers in their study received a great deal of attention in social media, with Twitter and Mendeley being the most popular media platforms. However, the datasets of the existing studies are mostly limited to the period before 2021 and have not yet covered the data during the stable period of the epidemic. This leads to a smaller amount of valid data for the study, which may affect the comprehensiveness and accuracy of the conclusions. Existing studies mainly focus on static analysis of AAS, lacking a dynamic perspective to offer in-depth interpretations of the data and a thorough understanding of its development and evolution. Additionally, these studies focus on the distribution characteristics of altmetric indicators, but overlook detailed content analysis.

The study focuses on COVID-19, using Retraction Watch and Altmetric.com as the main data sources. Combining the landmark events in the life cycle of a retracted paper, it explores the social impact and negative effects of these actively or passively "disappeared" retracted papers. The several research questions are proposed as follows:

Q1: How do retracted papers acquire attention in the social field from a dynamic perspective?

Q2: What social impact do retracted papers generate across social attention, public dissemination, and policy making during a public health emergency, and what potential negative effects may they trigger? Especially in terms of policy making, what are the motivations for mentioning retracted papers in policy documents, and what content are mentioned?

Q3: Is it possible for a retracted paper to trigger a cascading impact in both

academic and social fields? how this impact unfolds, and what consequences it leads to?

Data collection

This study searched for papers with "COVID-19" or "SARS-CoV-2" in the title from Retraction Watch database. In addition, the papers listed under "Retracted coronavirus (COVID-19) papers" were also included in the dataset. A total of 328 records were obtained, involving 299 retracted papers with basic information, reason for retraction, and retraction time. The data collection was completed on June 28th, 2023. To ensure the accessibility of the subsequent data, conference abstracts, conference papers, and preprints were excluded. Ultimately, this study obtained 253 papers, whose publication and retraction time are shown in Figure 1. Altmetrics data collection was completed on August 13, 2023, including AAS, values of altmetric indicators, etc., for retracted papers.

In terms of discipline distribution, the 253 COVID-19 retracted papers cover all major disciplines of Retraction Watch (shown in Table 1). Health science was the most predominant, followed by business and technology. Since 106 papers belong to more than one discipline, double counting was carried out in this study. Pharmacology had the highest number of retracted papers among all sub-disciplines. Two hundred and fifty-three papers were from 65 countries and regions. Fifty-nine of these papers were multinational collaborations, and only the country of the first author was counted. The United States and China tied for first place, both with 40 retracted papers, representing 15.8% of the total 253 retracted papers; the Republic of Malta came in third. Of the 28 retracted papers, 27 were from the same journal, *Early Human Development*. Twenty-one of these papers were retracted on the same day, but none of the retraction notices mentioned a specific reason for the retraction. India, Pakistan, Spain, the UK, Egypt, Brazil, and Iran rank from 4th to 10th.

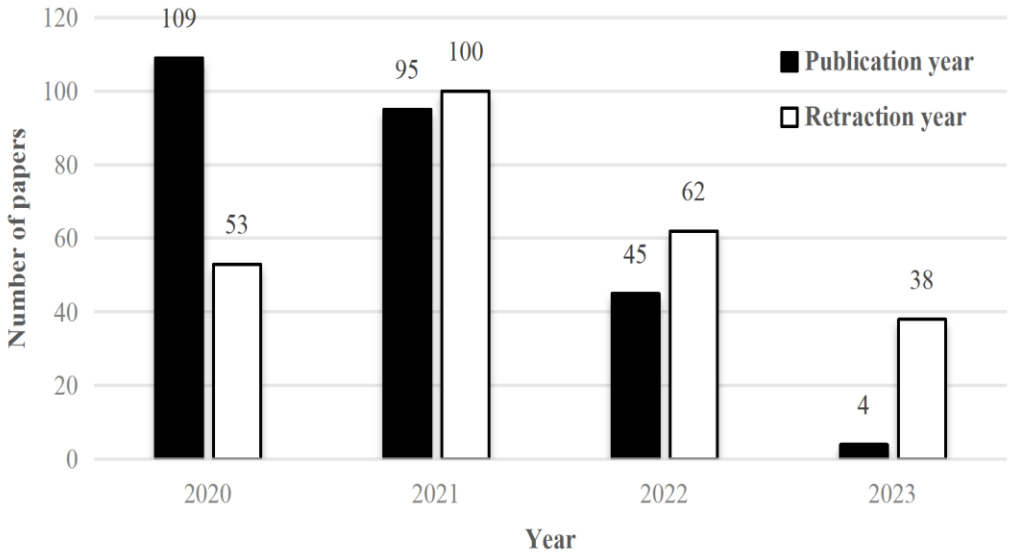

Figure 1. Publication and time distribution of 253 COVID-19 retracted papers.

Table 1. Discipline distribution of COVID-19 retracted papers.

Discipline	Sub-discipline (number of retracted papers)	Number of retracted papers
Health Sciences	Pharmacology (245), Public Health and Safety (51), Biostatistics/Epidemiology (38), Occupational Health and Safety (19), Radiology and Imaging (7), etc.	250
Business and Technology	Business (19), Data Science (14), Technology (14), Computer Science (12), etc.	55
Social Sciences	Sociology (14), Education (13), Psychology (9), Communication (2), etc.	41
Basic Life Sciences	Toxicology (7), Microbiology (7), Biochemistry (7), etc.	23
Physical Sciences	Physics (2), Geology (1), etc.	5
Environmental Sciences	Environmental Science (4), Food Science (1), etc.	5
Humanities	Journalism (3), etc.	5

Analysis method

Serious retraction problems erupted during the COVID-19 pandemic, damaging the scientific research ecosystem jointly built by researchers, the public, and the government. It aroused the concern of the academic community about the value of academic achievements. Meanwhile, the community is also paying close attention to the impact of retracted papers on policy-making, public opinion and the social environment. To gain a deeper understanding of the impact of retracted papers among

a wider audience, this study focuses on two landmark events: paper publication and retraction notice release. On the one hand, once a paper is published, its social impact will follow and the paper's characteristics may affect the public's attention and cognition. On the other hand, the release of retraction notices marks the change of the paper from normal to retraction, and the impact of the retracted paper may change. As the key indicators of the landmark event, the delay in retraction and reason for retraction could provide an important reference basis for analyzing the potential social impact of retracted papers. To explore the entire process of purification of scientific research environment, we characterize social impacts with the help of altmetric indicators. On this basis, this study will systematically analyze the multidimensional impacts generated by COVID-19 retracted papers. The research framework is shown in Figure 2.

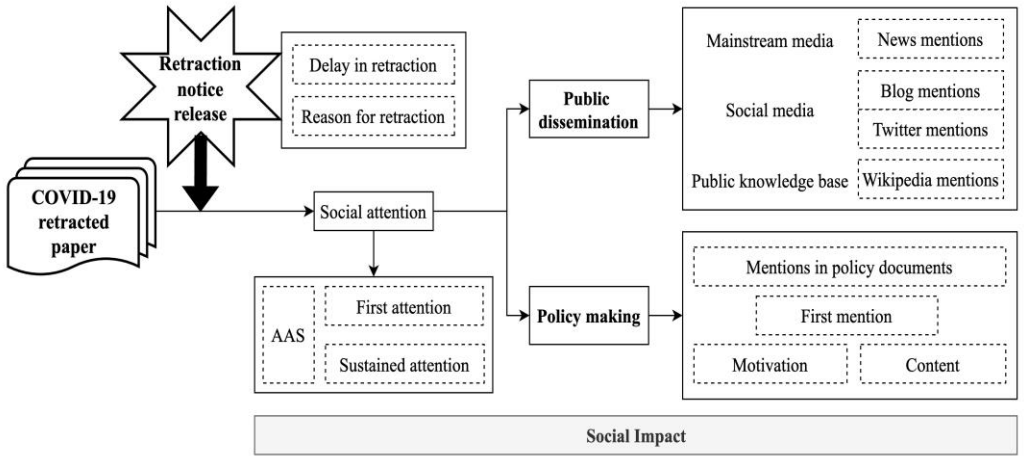

Figure 2. Research framework.

Retraction notice

This study analyzes retraction notices from two aspects: delay in retraction and reason for retraction. The delay in retraction is the time interval between paper publication and the release of retraction notice, which is an important indicator to measure the purification timeliness of retracted papers. Rapid response and timely action by academic institutions or journals can curb the potential negative impact of retracted papers. This study found that 35 of the 253 retracted papers were retracted on the day of publication. Of these, 22 papers did not specify the reason for retraction, and 7 papers were duplicates due to publisher error. The mean delay in retraction for the remaining 218 retracted papers was 249.5 days, with a median of 175 days. The article with the longest delay in retraction is *A topic-based hierarchical*

publish/subscribe messaging middleware for COVID-19 detection in X-ray image and its metadata. After 952 days of publication, this article was retracted along with other articles for academic misconduct, including false peer review and improper citation, in a series of retractions from Soft Computing on May 29, 2023.

Due to the complexity of the reasons for retraction, a unified classification system has not yet been formed. Referring to existing research, the study analyzes 253 paper retraction notices and classifies the reasons for retraction into academic misconduct (137 papers, accounting for 54.2%) (Bar-Ilan & Halevi, 2018) and scientific error (66 papers, accounting for 26.1%) (Ma et al., 2023; Xie et al., 2022). In addition, some papers (58 papers, accounting for 22.9%) were classified as "other" due to the absence of a retraction statement or lack of a specified reason for retraction. The specific distribution is shown in Table 2. Among them, 67 papers involved multiple reasons for retraction and were counted repeatedly. Academic misconduct usually includes plagiarism, inappropriate authorship, ethical violations, and so on. Scientific error is more concerned with problems in scientific research in terms of the rigor of experimental design, reliability of data sources, and accuracy of methodology, including incorrect/unreliable data, incorrect/unreliable results, and so on. Retracted papers containing scientific distortion and unreliable knowledge are considered as a barrier to the advancement of science (Bar-Ilan & Halevi, 2018). Especially in public health emergencies, academic achievements play an indispensable role in supporting epidemic prevention and control. Therefore, the impact of retracted papers due to scientific errors is particularly crucial.

Table 2. Distribution of reasons for retraction of COVID-19 retracted papers.

Primary classification of reasons for retraction	Secondary classification of reasons for retraction	Number of retracted papers	Proportion
Academic Misconduct	False peer review	42	16.94%
	Duplicate publication due to publisher error	22	8.87%
	Improper citation	21	8.47%
	Violation of experimental ethics	19	7.66%
	Duplicate publication	18	7.26%
	Plagiarism	16	6.45%
	Inappropriate attribution	13	5.24%
	Conflict of interest	7	2.82%

	No data rights	5	2.02%
	Copyright notice	4	1.61%
	Artificial Intelligence Generated Content	4	1.61%
Scientific Error	Incorrect/unreliable results	45	18.15%
	Incorrect/unreliable data	26	10.48%
	Analysis error	20	8.06%
	Text error	7	2.82%
	Method error	6	2.42%
	Image error	4	1.61%
Other	No specific reason for retraction	49	19.76%
	No retraction notice	10	4.03%

Social impact

Social impact refers to the influence or benefit that academic achievements bring to public cognition, public policy, public service, economy or culture. Many scholars use Altmetrics as a potential indicator for measuring social impact, effectively supplementing traditional scientometrics with diverse and comprehensive data sources (F. Guo et al., 2016; L. Guo & Zhou, 2023). Among them, AAS can reflect the degree of attention to paper outside the academic community. Yu Houqiang et al. (2014) divide altmetrics indicators into three levels of dissemination, access and utilization to analyze the deepening degree of the social impact. González-Betancor S M et al. (2023) consider that each type of digital platform where a paper is mentioned reflects a different dimension of influence than the academic one: media influence (mentions in mainstream news), social media influence (mentions in Twitter), educational impact (mentions in Wikipedia) and political influence (mentions in public policy reports). It is possible to quantify the task of knowledge transfer to society multidimensionally (Arroyo-Machado et al., 2022). Combined with the rich data provided by Altmetric.com, this study explores the impact of retracted papers through public dissemination and policy making.

At the social attention level, the first attention marks the moment the paper first gains public prominence. The interval between paper publication and first attention reflects the timeliness of the paper's social attention. The sustained attention is the time interval between the last AAS update and the first attention. Considering that some papers still receive attention during data collection, the sustained attention of these

papers is set as the interval between the first attention and data collection date (2023/08/13). For public dissemination, the social impact of COVID-19 retracted papers is spread through diversified media. This study measures the dissemination through different media, including news reports (mainstream media), blog mentions (social media), Twitter mentions (social media), and Wikipedia mentions (public knowledge bases). At the policy making level, the number of policy documents mentioning the papers is used to measure the paper's utilization. The motivation and method of mentioning the paper in the policy documents are analyzed to further understand the interactive relationship between academic research and policy-making, which reflects the impact of academic achievements on policy-making.

Results

Social attention

AAS is calculated based on the attention of various sectors of society, such as government departments, mainstream news media, social networking sites and peer review platforms. It is usually considered to reflect the social impact produced by the papers. Seventy-nine of 253 retracted papers had an AAS of 0, accounting for 31.2%. The remaining 174 papers had an average AAS of 1,044.67. The 8% of the retracted papers (designated as Papers A) accounted for 85% of the AAS. This suggests that the social impact of retracted papers is highly concentrated. The majority of Papers A belong to the field of health sciences, involving topics such as therapeutic drugs, comorbidity studies, vaccination and mask protection effects. This differs from the main topics of highly cited papers (citation frequency >100), which are more related to therapeutic drugs, complication research and public mental health. In Papers A, the United States ranks first where the papers are from, accounting for 50%, and there is only one paper from China. The reasons for retraction are mostly in the category of scientific errors, including erroneous/unreliable results, data, and analysis, which reflects a more concentrated and heightened public concern for scientific errors. In the context of global public health emergencies, scientific knowledge is crucial for policy-making and public health. Once scientific errors in retracted papers are revealed, they may undermine the public trust in academia, and may even interfere with the formulation and effective implementation of relevant prevention and control policies. A similar phenomenon can be observed in a wider dataset. For example, Serghiou S et al. (2021) collected retracted papers from 2010 to 2015 across multiple disciplines. They found that the main reason for retractions of the most popular papers with an AAS of >20 was that the research results were unreliable.

The first attention and sustained attention reveal the timeliness and ongoing interest of social attention aroused by COVID-19 retracted papers. On average, 174 papers received social attention for the first time in 44.5 days after publication. Twenty-six papers (accounting for 14.9%) aroused social attention and discussion on the same day of publication. The average duration of attention was 298.6 days, with a maximum of 1,238 days. There were 50 papers (accounting for 28.7%) whose attention lasted only 1 day, which was a flash in the pan and was quickly overwhelmed by other information. In this study, the intervals between the first attention of the paper and its publication were counted using time intervals of 1 day, 7 days, 30 days, and 180 days. The distribution of specific intervals and their average duration of attention are shown in Figure 3. As the first attention interval decreased, the duration of attention increased significantly, indicating that the paper was able to gain social attention in a shorter period. Even after active or passive retractions, due to the popular topic labels, the negative impacts generated by papers cannot be effectively controlled immediately, and continue to trigger discussions over a longer period.

To explore how the rapidly generated social impacts of retracted papers change and their possible negative effects, this study takes *Facemasks in the COVID-19 era: a health hypothesis* (Vainshelboim, 2021) published in *Medical Hypotheses* and *6-month consequences of COVID-19 in patients discharged from hospitals: a cohort study* (Huang et al., 2021) published in *The Lancet* as examples. The two papers were published around the same time, and both quickly attracted social attention on the day of publication. They both lasted for more than 900 days and had AAS of more than 10,000. However, the evolution of their social impact is different. Specifically, the former did not cause significant social repercussions at the early stage of publication. However, on April 10, 2021, the authors of the paper posted a tweet related to the paper, which was deleted by the Twitter platform later that day. This series of events quickly triggered an outburst of attention from social media users, with 21,855 tweets in 11 days, producing a huge social impact. As the third-party agency issued a statement and the journal editorial board launched an investigation, the paper was formally retracted due to improper authorship, improper citation, and unreliable data. Since then, its social attention has declined, and the delay in retraction was 162 days. After the retraction notice release, a portion of the public still referred to the paper to support their personal views. Therefore, the potential negative effects of the paper persisted. The latter gained high social attention on the day of publication. The mainstream media, as the main force of dissemination, reported the paper more than 110 times on that day. As the author published

subsequent related research results, the paper continued to receive attention from society and was mentioned several times in policy documents. It was not until a reader questioned the data in November 2022 that the journal immediately launched an investigation and issued a notice of concern. Ultimately, the paper was officially retracted and republished with a statement six months later for data errors. The delay in retraction of the paper was 882 days, spanning multiple critical stages of the outbreak. The social impact and potential negative effects of the retraction cannot be ignored. As the paper was quickly republished after being retracted and the topic involved faded in popularity, the number of mentions of the original retracted paper on major platforms dropped significantly.

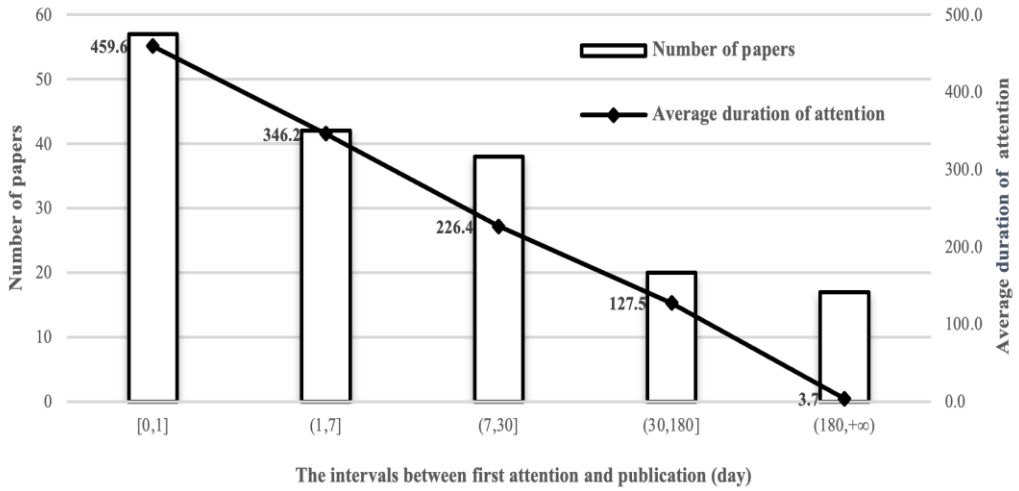

Figure 3. First attention distribution and average duration of attention.

Public dissemination

This study uses the numerical values and coverage of typical indicators to measure the dissemination of papers, as shown in Table 3. The coverage rate of altmetrics indicators, such as mainstream media and social media, of COVID-19 retracted papers is more than 40%. Some papers are mentioned multiple times by Wikipedia. It indicates that these papers' dissemination platforms are diverse and their social impact is wide. Twitter has the highest coverage of mentions, with a mean value of 1,608.95, and the overall dissemination intensity is relatively high. The main dissemination channels of COVID-19 retracted papers are consistent with the existing research (Liu, Sun, et al., 2022). The number of mentions on Twitter for different papers varies widely, with a range reaching up to 45,584. In contrast, blogs and mainstream media have a more balanced dissemination. Notably, retracted

papers that were widely reported by over 50 news media tended to have a shorter delay in retraction. Most of them were retracted within 50 days after publication, which could be a potential positive effect of media attention on the timeliness of purification. In addition, Wikipedia, as a public knowledge base with the core values of openness, inclusiveness and collaborative sharing, plays an important role in the dissemination and popularization of knowledge. Eighteen retracted papers were mentioned 113 times by Wikipedia entries. These entries cover (1) the terminology associated with COVID-19 and its complications, including the therapeutic agents like azithromycin, ivermectin and hydroxychloroquine; (2) the retraction records of academic achievements and instances of academic misconduct; and (3) the latest progress of related clinical trial programs. These entries provide the public with a wealth of professional, authoritative and continuously updated information to meet their concerns and requirements on the global issue of COVID-19. However, Wikipedia's public collaborative editing mechanism is unable to synchronize and update retractions in entries promptly, which contributes to the retention and continued dissemination of misleading information on the platform to some extent.

Table 3. Value of typical altmetric indicators.

Indicator	Coverage ratio	Mean	Median	Standard deviation	Maximum	Minimum
News Mentions	42.5%（74）	75.26	8	239.96	1 692	1
Blog Mentions	52.9%（92）	5.23	1	14.14	107	1
Twitter Mentions	92.5%（161）	1 608.95	5	5 467.36	45 585	1
Wikipedia Mentions	10.3%（18）	6.27	2.5	9.16	33	1

Note: The value in brackets of coverage ratio is “the number of papers with non-zero indicator values”.

Policy making

The mention of academic achievements in policy documents is an important manifestation of their social impact. Especially in public health emergencies, academic papers provide important scientific guidance for relevant policy-making, which has led to an increased emphasis on science in policy decisions (Ren et al., 2023; Yin et al., 2021). Fourteen COVID-19 retracted papers were mentioned in 41 policy documents, among which 10 papers were all retracted due to scientific errors, including incorrect/unreliable data or results, and analysis errors. To further explore the possible negative effects of COVID-19 retracted papers on the scientificity of

epidemic prevention policies, the study analyzed the characteristics of policy document mentions from three aspects: first mention, motivation of mention, and content of mention. Excluding two policy documents for which the original text was not available, 39 policy documents were obtained as a sample. Referring to existing research (Yu et al., 2023) and combining the experience in the coding process, the study developed a content analysis coding table for the motivations and content mentioned in policy documents, as shown in Tables 4 and 5.

Table 4. The coding table of motivation mentions in policy documents.

Primary coding	Secondary coding	Explanation
M1 Background Mention		Introduce an issue and explain the background or significance of the policy.
M2 Support Mention	M2.1 Source Support	Provide sources for concepts, data, theories in policy documents.
	M2.2 Methodological Support	Justify the research methodology or data processing of the policy document.
	M2.3 Argument support	Provide support for arguments, including conclusions or facts.
M3 Construction Mention	M3.1 Indicative orientation	Indicate relevant papers to rich background knowledge or trace the origins of different research perspectives.
	M3.2 Argument base	Formulate new ideas based on the content of the paper.
	M3.3 Meta-analysis	Meta-analyze the data, models from papers as the research content of policy documents.
	M3.4 Scientific review	Review scientifically, discuss and even criticize the papers mentioned.
M4 Unable to Judge	M4.1 Incidental mentions	Mention in appendices, reports or papers included in the policy documents.
	M4.2 Pure mention	No element of the paper is mentioned, and the motivation is vague.

Table 5. The coding table of content mentions in policy documents.

Primary coding	Secondary coding	Explanation
C1 Content	C1.1 Title	Mention the title of the paper exactly.
	C1.2 Abstract	Mention the abstract of the paper, either completely or partially.
	C1.3 Methodology	Mention the methods or models applied in the paper.
	C1.4 Conclusion	Mention the conclusions, discussion, and recommendations of the paper.
C2 Entity	C2.1 Fragments	Mention fragments of the paper, including concepts, ideas, diagrams, paragraphs, etc.
	C2.2 Tools	Mention software, websites, databases, etc., used in the paper.
C3 Generalization	C3.1 Topics	Mention the topic, central question, or research area of the paper.
	C3.2 Overview	Briefly describe, summarize, or evaluate the paper's main content.
	C3.3 Indirect mention	Mention multiple papers in a single sentence and summarize their common features in a particular aspect.
C4 Pure links		No element of the paper's content is mentioned.

This study quantifies the speed of academic achievements in influencing policy documents by the interval between publication and the first mention. The study found that papers were first mentioned in policy documents on average 77.5 days after their publication. Eleven retracted papers (78.6%) were mentioned in policy documents within 180 days of publication. This indicates that the COVID-19 epidemic has strengthened collaboration and dialogue between academics and policymakers, thereby expediting the translation of academic knowledge into policy-making. In addition, this phenomenon is also related to the shortened release cycle of epidemic prevention policies. For example, *the COVID-19 Clinical Management: Dynamic Guidelines* issued by the World Health Organization is updated at least twice a year, ensuring that the recommendations and standards are always based on the latest scientific evidence. However, high-intensity dialogue between the two parties may lead to an inadequate assessment of the quality of papers in policy documents. Due to the controversial nature and unreliable knowledge of retracted papers, the degree of effect on policy development needs to be further assessed.

In terms of motivation, policymakers introduce academic achievements into policy documents, aiming to promote the transformation of knowledge from academic research to policy decision-making, and improve the scientific nature of policies, and enhance the pertinence and implementation effect of policies. The analysis results of the motivation are shown in Table 6. It was found that 64.1% were to find relevant

evidence for policy documents. Research related to pathological manifestations, complications and antiviral drugs based on COVID-19 can support the development of more effective preventive measures, especially as the arguments and data in policy documents. For example, *Clinical Management of COVID-19: Living Guideline* issued by the World Health Organization states that "there is no research that demonstrates a significant effect of antihypertensive medications on the patient's clinical course, and it is generally recommended to continue using such medications." This argument is supported by the paper *Cardiovascular disease, drug therapy, and mortality in COVID-19*. However, after the article was retracted on June 4, 2020, a series of dynamic guidance documents issued from January 25, 2021, to January 13, 2023, continued to mention the paper as the evidence and did not mark its retraction status. The second most common type is "Construction mention", using elements such as data and models as the foundation for viewpoints in policy documents. A small number of policy documents were designed to analyze the risk of bias in the papers. For example, the *COVID-19 Rapid Guideline: Managing COVID-19* conducted a scientific review of the paper *Remdesivir efficacy in COVID-19 treatment: a randomized controlled trial*. The NICE Expert Advisory Group was seriously concerned about the risk of bias. This paper was retracted 191 days after the guideline was released. In addition, there was one policy document that referred to papers in the appendix section, stating only when and why they were retracted, but without mentioning the motivation.

In terms of mentioned content, this study categorizes the mentions based on the structure of papers to understand which parts of papers have had a significant impact on policy formulation. The results are shown in Table 6. In the dataset, 46.2% of the policy documents mentioned the contents of the conclusion and discussion, which corresponds to the "argument support" with the highest proportion of motivation. Secondly, there is a high proportion of "overview" and "indirect reference". The former mostly summarizes the main content of the paper or evaluates the possible risk of deviation. The latter does not directly mention the specific content of a paper, but summarizes the common features of several papers in one sentence, making the reference source richer. The study concludes that policy documents are more focused on the research content. When mentioning content, policymakers tend to choose conclusions that have practical support for the policy document itself.

Table 6. The coding results of motivation and content mentions in policy documents.

Mention of motivation coding	Proportion	Mention of content coding	Proportion
M1 Background mention	5.1%	C1 Content	51.3%
M2 Support mentions	64.1%	C1.1 Title	0
M2.1 Source support	17.9%	C1.2 Abstract	5.1%
M2.2 Methodological support	0	C1.3 Methods	0
M2.3 Argument support	46.2%	C1.4 Conclusion	46.2%
M3 Construction mention	25.6%	C2 Entity	2.6%
M3.1 Indicative orientation	12.8%	C2.1 Fragments	2.6%
M3.2 Argument base	0	C2.2 Tools	0
M3.3 Meta-analysis	7.7%	C3 Generalization	41.0%
M3.4 Scientific review	5.1%	C3.1 Topics	2.6%
M4 Unable to judge	5.1%	C3.2 Overview	17.9%
M4.1 Incidental mention	2.6%	C3.3 Indirect mention	20.5%
M4.2 Pure mention	2.6%	C4 Pure links	5.1%

Impact cascade phenomenon of retracted papers

Cascade refers to the chain reaction in which an event or behavior triggers a series of related events or behaviors. In the process of citation diffusion, a paper triggers a series of subsequent citations, which is called a citation cascade. Similarly, in the process of information diffusion, the information spreads layer by layer among social media users, forming a huge cascade. The above two are intertwined, which together constitute the impact of COVID-19 retracted papers in academia and society, like ripples spreading on the surface of the water, triggering a sustained and extensive chain effect.

To demonstrate more intuitively the possible negative effects of retracted papers in academia and society, this study selected the paper with the highest AAS as a typical case. The title of the paper is *Ivermectin for prevention and treatment of COVID-19 infection: a systematic review, meta-analysis, and trial sequential analysis to inform clinical guidelines* (noted as paper #1). This paper mainly found the effectiveness of antiparasitic ivermectin in reducing the risk of death in people infected with COVID-19 or high-risk groups through a meta-analysis of 15 randomized controlled trials. In terms of citation diffusion, paper #1 was cited more than 50 times by the academic community before it was “expressed as a concern”. For example, Boretti A (2022) suggests the best way to treat COVID-19 infections and indirectly treat Nigella sativa infections based on the results of paper #1 (cited as paper #2). Santin A D et al. (2021) cite paper #1 as one of the notable evidence in support of ivermectin's efficacy in reducing COVID-19 mortality (cited as paper #3). Paper #3 has also been cited 11 times to the present day, with an AAS of 17,121, having a significant social impact.

In terms of information diffusion, paper #1 has attracted widespread social attention since its publication, with 45,585 Twitter mentions and has been mentioned on blogs, mainstream media, and multiple types of communication platforms such as Wikipedia. Paper #1 was still being discussed by the public at the time of data collection for this study. Numerous related reports have led the public to believe in the effectiveness of ivermectin, and even to view it as a stopgap measure in the event of a vaccine shortage. However, as of now, health authorities such as the U.S. Food and Drug Administration (FDA) (2021) has recommended against using ivermectin for COVID-19 treatment outside of clinical trials, citing insufficient evidence of its efficacy and safety.

The veracity and reliability of Paper #1 have been questioned due to claims of data collection or reporting flaws in at least two of the data sources it incorporates. Specifically, one of the data samples that were the subject of the allegations was a paper published by Elgazzar A et al. (2020) based on the results of a clinical trial (notated as Paper #4) claiming that ivermectin reduced mortality from neocoronaryngitis by more than 90%. This paper was ultimately retracted by the preprint server Research Square due to possible plagiarism and data manipulation issues. After evaluating paper #1, the journal editors labeled the study "Expression of Concern" (Manu, 2022; Reardon, 2021) because they believed that the exclusion of questionable data, such as paper #4, might invalidate the study's results. Until the end of data collection in this study, the investigation of the allegations against the data sample of paper #1 remained inconclusive, which had a lasting negative effect on the meta-study and led to a cascade of negative impacts in subsequent academic research and social dissemination (shown in Figure 4).

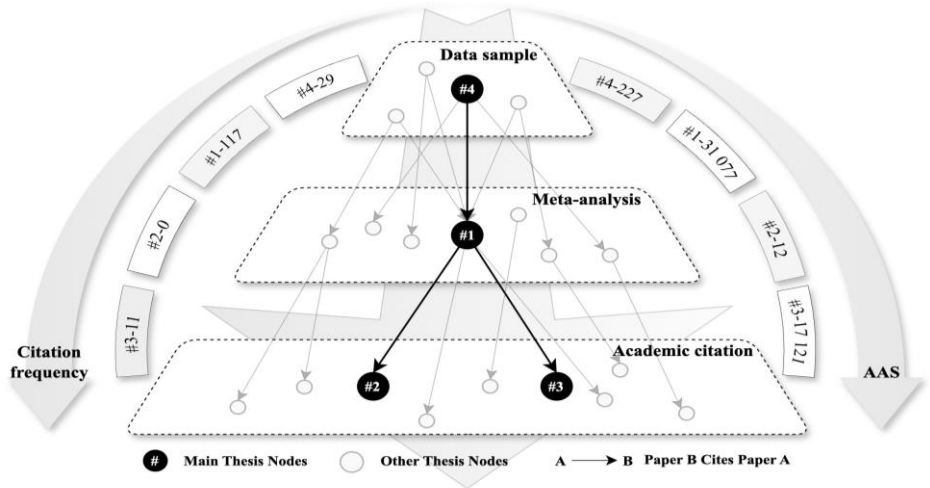

Figure 4. Illustration of the cascading impacts of COVID-19 retracted papers.

Discussion and conclusion

With the help of altmetric indicators, this study explores the social impact in terms of social attention, public dissemination, and policy making. Taking typical papers as an example, we analyze the cascade of impacts that may be triggered by COVID-19 retracted papers. The main findings and inspirations of this study are as follows.

The social impact of retracted papers is closely related to two landmark events: the publication and the retraction notice release. Among the hot papers that receive widespread public attention, the distribution of disciplines and countries shows significant concentration. Moreover, the release of retraction notices becomes a crucial window for researchers and the public to access detailed retraction information and respond to the potential negative effects. The delay in retraction, and the reasons for retraction play an important role in shaping its societal impact. However, a large number of papers with short retraction delays lack specific retraction reasons. In addition, in public discussions, not only the paper's research findings but also the retraction event and its reasons play a central role.

COVID-19 retracted papers exhibit a high average AAS, with a highly concentrated distribution of social impact, as 8% of the papers attract nearly 80% of the total attention. Notably, only a few problematic papers triggered retractions, but they caused widespread ripple effects, misleading subsequent research and public cognition. COVID-19 retracted papers attract differing attention from the academic community and the public. Through diverse media channels, they often reach broader audiences, with faster public engagement associated with longer-lasting discussions. Twitter shows the highest mention coverage, reflecting high overall dissemination, while intense news media coverage helps speed up the retraction process and improves corrective timeliness.

Moreover, COVID-19 retracted papers have a faster rate of impact on policy documents, averaging only 77.5 days from publication to citation. In policy documents, retracted papers — often withdrawn due to scientific errors — are primarily cited for practical purposes, with references typically made to their conclusions and discussions to support policy considerations. Fortunately, 87.2% of policy documents used standardized formats for paper mentions, which aids in automatic identification.

The characteristics of the paper, the delay in retraction and the reasons for retraction play an important role in the impact generated by the retracted paper

A large number of papers without a specific reason for retraction indicates that

journals should not only improve the timeliness of academic purification but also pay attention to the standardization of retraction notices and the normality of the retraction process. Furthermore, the gradual shift of social attention to the potential risk of retraction may continue for a long period after the retraction notice is released. In addition to the research results of the paper, the retraction event and the reasons for it also occupy an important position in the public discussion.

In purification, we should not only be highly alert to the risk of subsequent research due to scientific errors in papers but also resolutely prevent and crack down on academic misconduct. Especially in emergencies such as the COVID-19 epidemic, which urgently require rapid response and precise guidance from the scientific community, the maintenance of academic integrity is even more urgent. Retractions caused by academic misconduct may trigger a crisis of public trust in science and affect public perception of epidemic prevention measures (Yuan & Liu, 2024), which may have significant and difficult-to-eliminate negative social impacts.

The influence is highly concentrated, and there are differences between researchers and the public

Only a small number of papers that meet the urgent needs of the public can quickly gain a large amount of attention. Among these highly concerned papers, only very few may be problematic retracted papers. However, it is these papers that may cause great waves and trigger a sustained and extensive ripple effect. In turn, these papers misdirect the subsequent research direction and public cognition, leading to an overall information epidemic.

In addition, there are differences in the focus of academia and society on the COVID-19 retracted papers. The dialogue between researchers and the public on cutting-edge issues is not entirely equal, which affects the public's correct cognition of retracted papers. This suggests that researchers should take social responsibility in public health emergencies, pay attention to public needs and concerns, and give full play to the social value of scientific research by solving practical problems.

Considering the prompt and responsive social attention, news media and social media should cooperate to improve the timeliness of academic purification

Supported by open-access initiatives and social media platforms, the discussion of papers is no longer limited to scholars but has become the focus of a wider audience through various media. Khan H et al. (2022) have found that retracted papers may be more likely to receive extraordinary attention on social media platforms than non-retracted papers, especially for papers that the public can readily perceive as problematic. Similar to the findings of this study, COVID-19 non-retracted papers

exhibit “slow” dissemination characteristics (Mehra et al., 2020). This suggests that social media has a role to play in identifying “unreliable” papers, combating rumors, and popularizing science. Da Silva J et al. (2019) also mention that anonymous comments about academic misconduct are becoming commonplace on social media platforms such as Twitter. These comments tend to be quickly noticed and widely disseminated. In addition, the high attention of news media has a positive effect on accelerating the timeliness of retraction purification.

Therefore, the relevant regulatory authorities should fully allow the news media to guide mainstream public opinion, grasp the dissemination characteristics of social media, and prioritize the monitoring of academic achievements that are highly popular on these social media platforms. This can enhance the probability and speed of monitoring retraction through public opinion, thereby enhancing the timeliness of retraction purification, reaching the optimal effect of public memory correction during the period of social attention.

The dialogue between academia and policymakers has been strengthened, and papers mentioned in policy documents should be rigorously monitored

Compared with our study, Yu Houqiang et al. (2017) based on more than 90,000 policy document mentions collected from 2013 to 2016, found that less than 12% of papers were mentioned within 180 days, with an average delay of 4.5 years. This highlights that during COVID-19, multiple institutions, including medical, surveillance and scientific research, worked closely together and focused on relevant scientific research activities. This greatly strengthened the cooperation and dialogue between academics and policymakers and accelerated the speed of knowledge transformation in policy-making.

The policy documents primarily mention retracted papers for scientific error to utilize their conclusions and discussion sections, with minimal academic exploration and critique of the flawed papers. This may pose a potential threat to the scientific validity and efficacy of policy formulation. Furthermore, policy documents used standardized description formats when mentioning papers will improve the correct identification rate of automated processing of large batches of data and facilitate wider research. In addition, policymakers should rigorously monitor papers mentioned in policy documents, adequately assess the quality of papers, and make timely adjustments and updates in policy documents based on changes in the status of the papers. Therefore, it is important to maintain a constant focus on potentially defective papers and to mark their retracted status promptly. The negative effect of retracted papers must be minimized while taking full advantage of the authoritative information on academic achievements.

Limitations

This study has certain limitations, as it solely relies on altmetric indicators to analyze the impact of the papers, with content analysis focusing exclusively on the characteristics of mentions in policy documents. It does not comprehensively examine the mention characteristics of retracted papers across various dissemination platforms. Future research will adopt a media dissemination perspective to investigate the social impact of academic papers, with the goal of optimizing the dissemination model of research outputs, enhancing their visibility and recognition within the social domain, and developing a more robust and comprehensive system for evaluating the social impact of academic achievements.

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